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Recent Advances in Artificial Culture of Salmon and Steelhead Trout of the Columbia River

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Cover photo.—Indian gill net fishing in the Columbia River.

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By

FRED CLEAVER

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Recent Advances in Artificial Culture of Salmon and Steelhead Trout of the Columbia River

By

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ABSTRACT

The catch of salmon and steelhead trout from fish reared in Program hatcheries increased rapidly beginning in 1964. By 1967 the benefits from operation of these hatcheries appeared to be well in excess of their costs. The Oregon moist pellet diet was the greatest single factor in providing an economically favorable operation.

Further advances in hatchery efficiency are expected in the next few years. Conservation agencies believe that the catch of hatchery-produced Columbia River fall chinook salmon, coho salmon, and steelhead trout can be increased substantially and that the cost per unit of production can be decreased.

INTRODUCTION

The Columbia River Fishery Development Program was undertaken in 1948 to offset losses of salmon and steelhead trout caused by Federal water development projects. The Program is financed through the Bureau of Commercial Fisheries, and the greater part of the funds available has been used to construct and operate hatcheries. The rest of the funds has been used to improve the natural habitat and to make limited investigations that give immediate answers to problems associated with producing more salmon. The work has been done mainly by contract with the fish and game conservation agencies of Idaho, Oregon, and Washington and with the Bureau of Sport Fisheries and Wildlife. The names of the hatcheries, the names of the agencies that operate them, and the names of the fish produced are listed in table 1. Steelhead trout released from the hatcheries are caught only in the Columbia River system, whereas most of the salmon are caught at sea from California to Alaska.

The operating agencies have made major contributions, beyond those required by contract, to the success of the Program. All have research groups that study ways to improve the operations of the fish culturists. The diet research of the Fish Commission of Oregon, for example, has enabled the hatcheries to raise higher quality fingerlings at a lowered cost. This diet plus improved hatchery management procedures have resulted in higher production than was thought possible a decade ago.

Table 1.—Hatcheries operated under the Columbia River Fishery Development Program

Hatchery	Operating agency	Species of fish reared
Gnat Creek	Oregon State Game Comm.	Steelhead
Big Creek	Fish Comm. of Oregon	Chinook, coho, chum, steelhead
Bonneville	Fish Comm. of Oregon	Chinook, coho
Cascade	Fish Comm. of Oregon	Chinook, coho

Table 1.—Hatcheries operated under the Columbia River Fishery Development Program - Continued

Hatchery	Operating agency	Species of fish reared
Klaskanine	Fish Comm. of Oregon	Chinook, coho, steelhead
Ox Bow	Fish Comm. of Oregon	Chinook
Sandy	Fish Comm. of Oregon	Chinook, coho
Beaver Creek	Washington Dept. Game	Steelhead
Skamania	Washington Dept. Game	Steelhead
Elokomin	Washington Dept. Fish.	Chinook, coho
Grays River	Washington Dept. Fish.	Chinook, coho
Kalama Falls	Washington Dept. Fish.	Chinook, coho
Klickitat	Washington Dept. Fish.	Chinook, coho
Toutle	Washington Dept. Fish.	Chinook, coho
Washougal	Washington Dept. Fish.	Chinook, coho
Abernathy	Bureau Sport Fish. Wildl.	Chinook
Carson	Bureau Sport Fish. Wildl.	Chinook, coho
Eagle Creek (Clackamas)	Bureau Sport Fish. Wildl.	Chinook, coho, steelhead
Little White Salmon	Bureau Sport Fish. Wildl.	Chinook, coho
Spring Creek	Bureau Sport Fish. Wildl.	Chinook
Willard	Bureau Sport Fish. Wildl.	Coho

HATCHERY PROGRAM

Between 1948 and 1962, 21 hatcheries were constructed or remodeled on tributaries to the lower 180 miles of the Columbia River. By 1962 some people doubted that the hatcheries contributed enough salmon and steelhead trout to justify their costs; consequently further construction was deferred until the value of hatchery production could be measured. Fishery managers believed that hatchery fish made up a substantial part of the catch, but they could not prove it.

In 1962 the Federal Government, through the Bureau of Commercial Fisheries, contracted with the fisheries agencies of Alaska, California, Oregon, and Washington to participate in an appraisal study to determine how much hatchery-reared fall chinook and coho salmon contribute to the sport and commercial fisheries. In 1964 the Fisheries Research Board of Canada initiated a cooperative effort. Although field activities will continue through 1969, results from the first marking experiments on fall chinook salmon are now available. Bureau of Commercial Fisheries scientists have analyzed the catch and hatchery-return data on the fall chinook salmon that hatched from eggs taken in 1961 (Worlund, Wahle, and Zimmer, in press). Relations between the number of fall chinook salmon that returned to the hatcheries and the catch from this run of fish were developed from that analysis. If we assume that the catch to escapement ratio for the fall chinook salmon that returned to the hatcheries in 1967 (mainly 1963 and 1964 broods) was the same as for the 1961 brood, the harvest by sport and commercial fisheries was 4.8 million pounds in 1967.

Data on recoveries of marked fish and the catches from experimental lots of coho salmon are not yet complete, but the increased catches of coho salmon in the Columbia River and the Pacific Ocean suggest that the hatcheries have provided many valuable fish. During a period when the numbers of wild coho salmon in the Columbia Basin remained about the same from year to year, the returns to hatcheries and catches of hatchery-raised cohos increased sharply. Thus the improvement in the catches reflects larger yields from hatchery-reared fish.

The increases have been impressive. Figure 1 shows a strong rise in numbers of mature coho salmon that returned to the hatcheries between 1961 and 1967. Returns in the preceding years were lower than those in 1961. The returns to two of the hatchery streams in 1967 were so large that 164,000 maturing cohos were harvested and sold because they were not needed for spawning. Figure 2 shows that gill net landings also rose sharply between 1964 and 1967. A more gradual rise is reflected in the ocean troll catch off Oregon (fig. 3) and in the sport catch of coho salmon near the mouth of the Columbia River (fig. 4).

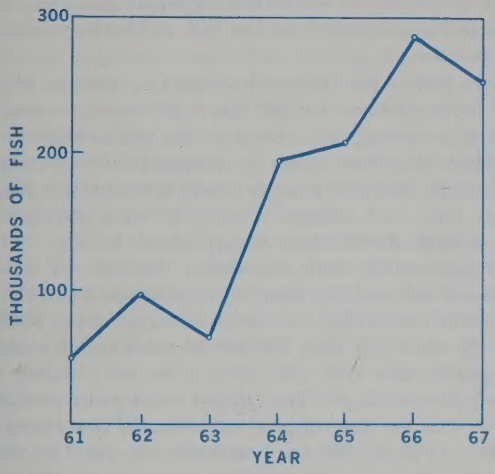

Figure 1.—Columbia River coho spawning escapement to hatcheries, 1961-67.

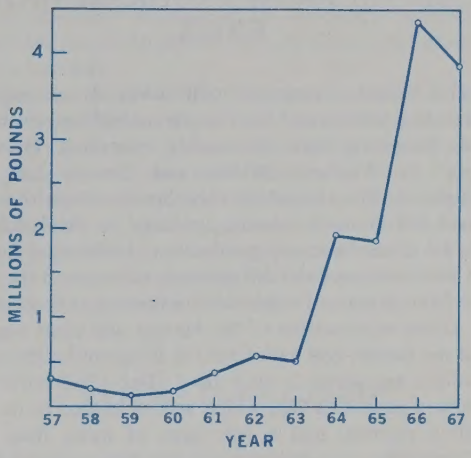

Figure 2.—Columbia River fall season cocho landings, 1957-67.

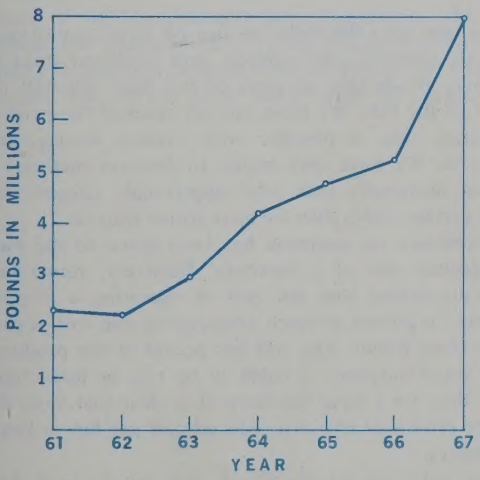

Figure 3.—Oregon ocean troll landings coho salmon, 1961-67.

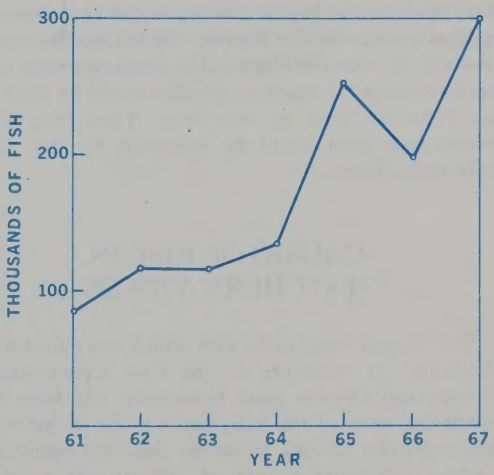

Figure 4.—Columbia River coho salmon sport catch, 1961-67.

The coho salmon produced by Program hatcheries provided an increased catch of coho salmon in the ocean fisheries and in the Columbia River between 1961 and 1967. This increase was about 10.5 million pounds in 1967.

More than 1,950,000 steelhead trout smolts were released in 1965 from Program hatcheries. If we assume, from available data, that 2.5 percent of these were caught (mainly by sport fishermen), the catch of hatchery-reared adult steelhead trout was 48,750 fish in 1967. At an average weight 7.5 pounds each, these fish weighed 365,000 pounds.

We estimate that the total catch of salmon and steelhead from Program hatcheries in 1967 was 15.7 million pounds and provided an important part of the catch in and near the Columbia River.

BENEFITS FROM PROGRAM HATCHERIES

The benefits compared with costs of rearing and harvesting salmon and steelhead trout in Program hatcheries have not been thoroughly examined. Only the report by Worlund, Wahle, and Zimmer has been completed. They found that the benefits from the 1961 brood fall chinook salmon produced in the hatcheries was 2.3 times the cost of production. Analyses of data for the 1962-64 broods of fall chinook salmon and the 1965 and 1966 broods of coho salmon remain to be completed. Gross examination of the harvest and costs suggests that the benefit-cost ratios for the Program hatcheries as a whole are about 2 or 3 to 1. The 1967 harvest of hatchery-produced fish, which was estimated to be 15.7 million pounds, had a net value of more than $7.5 million. The costs of producing the fish included a pro rata share of the $13.6 million invested initially in hatcheries and about $2.0 million annually for operation and maintenance.

These benefit-cost comparisons are for a period when the hatcheries were operated below their full capacity. Full operation of the hatcheries would add about 10.5 million pounds to the harvest. Operating and maintenance costs would be increased by about one-third by full operation, but the resulting benefits would be more than six times as great as the costs. Thus, the present benefit-cost ratio could be increased by full use of existing facilities.

CAUSES OF RISE IN HATCHERY YIELDS

The Oregon moist pellet diet, which was painstakingly developed by scientists of the Fish Commission of Oregon and Oregon State University, has been given credit for most of the increased success of hatcheries. Many features lacking in earlier diets, but essential for healthy and rapid growth of salmon and trout, are provided with the pellet. By 1960 all of the Fish Commission hatcheries were using this diet, and by 1962 all of the Program hatcheries had adopted it. There is a 2-year lag between the feeding year and the harvest year; thus, 1964 was the first year in which the full effects of better food were evident.

The new diet has several desirable qualities. Because it is pasteurized, several severe diseases that had been transmitted through food were controlled. Other diseases that cannot be controlled by pasteurization of the food can be controlled by medication that is incorporated in the diet. Soluble food elements are not lost into the water by leaching because they are bound together in the pellets. Sanitation in the rearing ponds is improved because there is little food lost that can harbor unwanted organisms.

We believe the Oregon moist pellet is the first step in the development of diets that will be even better in nutrition, storage characteristics, and ease of feeding.

Other important causes for increased hatchery production were the discoveries by fishery scientists that proper size, time, and location of releases were essential for good survival of hatchery fingerlings and smolts.

Experimental work has shown that survival of fall chinook salmon fingerlings to a harvestable size can be tripled if the fish are released at the larger size of 100 fish per pound rather than 200 per pound. The fall chinook fingerlings that were planted in 1968 were mainly 100 per pound or larger. The Oregon moist pellet permitted us to raise the fingerlings to this desirable size during the relatively short period of time before release. The effects of larger fingerlings should become evident in 1970 when the fish are in their third year of life and enter the fisheries.

FUTURE HATCHERY PRODUCTION

We now have the ability to furnish large quantities of chinook salmon, coho salmon, and steelhead trout by hatchery production at costs of less than one-half the value of the fish. We have not yet reached the peak of efficiency that is possible with present management practices. We have only begun to discover methods in animal husbandry that offer appreciably cheaper and more certain yields than we have gotten thus far.

Heretofore no attention has been given to the most economical size of a hatchery. Belatedly, researchers have discovered that the cost of operating a 10-pond hatchery is almost as much as operating one with several times more ponds. The cost per pound of fish produced by a small hatchery is liable to be two or three times more than for a large hatchery. It is clear that more fish can be produced and at a reduced cost per fish in larger hatcheries.

Fish culturists usually plan to rear fish for both short periods and long periods so hatchery facilities can be used throughout the year. Little information exists to help hatchery managers determine which rearing schedules provide maximum benefits. Development of systems for rearing optimum numbers of species within a hatchery and between Program hatcheries would increase harvests at little added cost.

Only rarely is a hatchery water supply entirely suitable for salmon and trout culture. The most common faults are insufficient supply, temperatures too low or too high for optimum fish culture, silt, and water-borne diseases. All of the hatcheries listed in table 1 suffer from one or more faults in water supply.

Burrows and Combs (1968) have developed a controlled environment for salmon propagation that can eliminate or greatly reduce these limiting factors.

The system described by Burrows and Combs allows expansion of rearing space and permits full use of the ponds throughout the year. It also reduces the silt problems and the quantity of intake water, and because of the smaller quantity of water, it simplifies control of temperature and sterilization of ponds.

For the first time we can now measure quickly the effects of changes in hatchery procedures. Sampling downstream migrant populations in the estuaries provides a good index of survival of hatchery-produced fish up to the time they are ready to enter the ocean. Before the hatchery fish are released and after they are recovered in the estuary, scientists of the Bureau of Sport Fisheries and Wildlife test them for stamina. Thru these tests we learn that the survivors are the larger, more vigorous fingerlings with higher reserves of usable fat. We can now describe, at least in part, the characteristics that a fingerling or smolt must have for maximum survival. We also can test the merits of releasing them at alternate times and places.

The possibilities for higher yields from improved strains of fish have scarcely been considered. Although salmon and steelhead have a wide range of growth and quality characteristics, both between species and within a species, few efforts have been made to provide for general improvement of hatchery stocks. Because many of the desirable characters are evidently hereditary, geneticists should be able to develop strains that produce greater harvests.

I have not described all the promising areas for more efficient production of salmon and steelhead trout. Methods of disease control, feeding systems, physical conditioning, and many other matters are under investigation. Improved methods appear to offer excellent opportunities for securing greater returns per dollar of cost. This bright promise can be realized if we can prevent further deterioration of the environment for salmon and trout in the Columbia River and its tributaries.

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